Three-dimensional position resolution in the 36-fold segmented GRETA prototype detector

K. Vetter, A. Kuhn, I.Y. Lee, R.M. Clark, M. Cromaz, M.A. Deleplanque, R.M. Diamond, P. Fallon, G.J. Lane, A.O. Macchiavelli, C.E. Svensson, F.S. Stephens

Last year we reported on the measurement of the three-dimensional position sensitivity in our two-dimensionally segmented GRETA prototype detector. A three-dimensional position sensitivity of 0.2 mm to 0.5 mm (RMS) has been obtained at 374 keV, depending on the position and the direction.

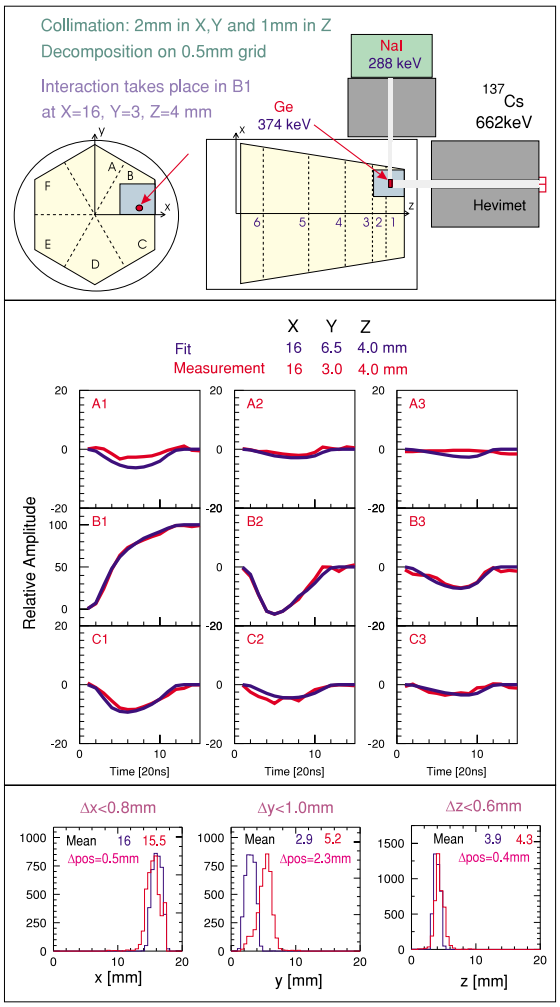

Figure 1: Top: Coincidence setup used to determine position resolution. Middle: Examples of measured (red) and calculated (blue) signals Bottom: Extracted positions (red:measured, blue: claculated)

However, due to the averaging of signals in the previous analysis, the sensitivity only reflected the relative change of the signal shapes for different positions as compared with noise. It largely neglected effects such as crystal orientation, absolute alignment, Compton profile, etc., which have to be taken into account to parameterize the measured signals theoretically and to extract positions on an event-by-event basis. Since it is impossible to experimentally map out signals on a sufficiently small grid throughout the whole crystal a theoretical parameterization is essential. To collect enough signals to determine a three-dimensional position resolution required 10 days of data collection on one position as indicated in fig.1 (top). Sets of 9 signals as shown in the middle part of fig.1 were calculated on a 0.5 mm grid after adjusting parameters such as the electronics response, impurity concentration and orientation of the crystal. For each event the location of the interaction was determined by comparing the measurement with calculated pulses. The signals in the middle part of the figure illustrate the excellent agreement between fitted (calculated) and measured signals. The lower part of fig.1 shows the extracted x,y, and z positions. While the agreement in terms of the shape of the position spectra is very good for all three dimensions, the location of the distribution in the y direction is off by about 2 mm. This is likely due to the dependence of the crystal orientation on the charge carrier drift direction which is not yet included in the pulse-shape calculations. Position resolutions of 0.8mm, 1.0mm, and 0.6mm were obtained for the x, y, and z directions respectively as shown in the lower portion of figure 1.